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Emissions of Nitrogen Oxides from the Testing of F404-GE-400 Engines at Naval Air Station, Lemoore, California

Aircraft Environmental Support Office
Naval Air Rework Facility
Naval Air Station, North Island
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Enclosure (3)

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EXECUTIVE SUMMARY

This report determined the weight of nitrogen oxides (NO_x) coming from thirteen different F404-GE-400 engine tests at NAS Lemoore. The weight of nitrogen oxides from each test was determined by adding the weights produced by each power setting used in the test. At each power setting, the amount of fuel used and the emission index for nitrogen oxides, which varies with the power setting, determine the amount of nitrogen oxides produced. The emission index is the pounds of nitrogen oxides produced per 1000 pounds of fuel used. This report used nitrogen oxides emission data furnished by the Naval Air Propulsion Center and F404-GE-400 engine run sheets from NAS Lemoore. The weight of nitrogen oxides produced varied from 50 to 169 pounds per test. The amount of nitrogen oxides for each pound of fuel used varied from 0.01331 to 0.01742 pounds, with an average of 0.01556 pounds. This average can be used as a correlation coefficient to estimate the amount of nitrogen oxides produced during an engine test on the basis of total fuel use only. To estimate the total weight of nitrogen oxides, multiply the weight of fuel used in the test by 0.01556.

Based on the thirteen engine test analyzed, the percentage difference between the amount of nitrogen oxides calculated from the emission indexes and fuel use at the various power settings, and from the total fuel use using the correlation coefficient, varied from -11 to +17. The total amount of nitrogen oxides calculated using this coefficient agreed within 1% of the total amount calculated from the emission indexes.

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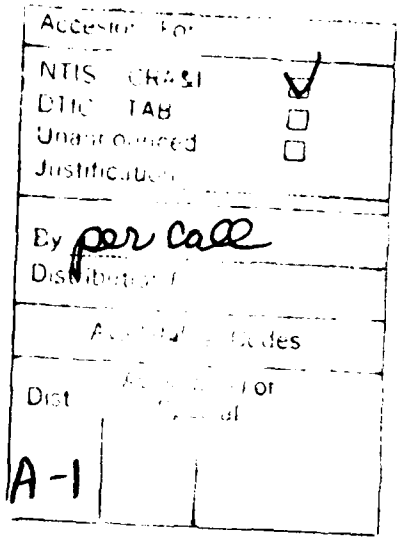

Emissions of Nitrogen Oxides from the Testing of F404-GE-400 Engines at Naval Air Station, Lemoore, California

1. INTRODUCTION

Nitrogen oxides, a combination of nitrogen oxide and nitrogen dioxide, are an air pollutant from the testing of aircraft engines. The amount of nitrogen oxides formed during an engine test is part of the information which must be included on applications to various regulating agencies for authority to construct and permission to operate test facilities. The emission indexes of nitrogen oxides at various engine power settings and the times at these settings determine the amount of nitrogen oxides coming from an engine test.

This report first develops emission indexes for nitrogen oxides at any power setting of the F404-GE-400 engine. It then applies these indexes to specific engine power settings and run times to give an estimate of the amounts of nitrogen oxides produced by thirteen different engine tests, in Test Cell 3, at NAS Lemoore. The dates of testing were from 8 March to 26 April, 1985. The amounts of nitrogen oxides from these tests varied from 50 to 169 pounds. The testing times were from 22 to 116 minutes. The pounds of nitrogen oxides formed, for each pound of fuel consumed during the test, varied from 0.01331 to 0.01742. The average from the 13 tests was 0.01556 pounds. This means that multiplying the pounds of fuel used in the test by 0.01556 would give a reasonable estimate of the pounds of nitrogen oxides formed during any engine test.

Finally, this report shows how to use a small programmable calculator to establish emission indexes and to estimate the amounts of nitrogen oxides produced during engine testing.

2. EMISSION INDEXES AND ENGINE OPERATIONAL DATA

2.1 Emission Indexes of Nitrogen Oxides at Various Power Settings

An emission index relates the amount of a pollutant in the engine exhaust to the amount of fuel used. Emission indexes are calculated from measured concentrations of carbon monoxide, carbon dioxide, nitrogen oxides and hydrocarbons in the engine exhaust.

This report considers only one pollutant, i.e., nitrogen oxides. The Naval Air Propulsion Center reported nitrogen oxide emission indexes for the F404-GE-400 engine at 14 different power settings (Reference 1). Appendix A includes Tables IV and V of Reference 1. The emission index for nitrogen oxides is different at each engine power setting, being smallest at idle and largest at full power (without afterburner). For use of these data, the Aircraft Environmental Support Office fitted the values of emission index and

thrust, from 15% thrust to IRP (intermediate rated power), to a curve using the exponential curve fitting program of the Hewlett-Packard HP-41C Statistics Pac. This program generated the constants a and b (a = 2.9747, and $b = 2.0127 \times 10^{-4}$) for use in the equation

$$y = ae^{bx}, \qquad (1)$$

where y = emission index and x = thrust in pounds.

Using the data from Reference 1, the coefficient of determination was found to be 1.00.

This report calculates an emission index for each thrust value recorded on the engine run sheets furnished by NAS Lemoore. Specific power settings may have different emission indexes. For example, for IRP, the thrust varied from 10000 to 10900 pounds. The emission indexes, calculated by equation (1), were 22.35 to 26.79. The thrust and emission index reported in Reference 1 for IRP were 10548 pounds and 25.16.

Reference 1 gave only one emission index for maximum afterburner. All afterburner power settings use this emission index, which is 9.22.

2.2 Engine Operational Data

Naval Air Station, Lemoore furnished engine run sheets for 13 tests. Appendix A includes reproductions of these run sheets. The engine run sheets contain 22 columns of data. Tables 2 - 14, of this report, use four of the data columns from these sheets, e.g., data identification, time, thrust and cell fuel flow.

2.2.1 Data Identification

The tables of this report use the same data identification notation as the engine run sheets. Data are identified as FI (flight idle), various rpm or percent rpm, IRP, and AB (afterburner). Note that 80% is about 13000 rpm and 89% 16500 rpm.

2.2.2 Time at Power Setting

For any row of data, the number in column 1 gives a start time for the data identified in column 22. The number in column 1 of the second row is the finish time for the data identified in column 22 of the first row and the start time for the data identified in column 22 of the second row. On some run sheets, the time at afterburner was not clearly defined. For these times we used 3 minutes and noted that the time was estimated.

2.2.3 Thrust

Several thrust values were missing from the data sheets. They were replaced by average values which were obtained from the other engine run sheets.

2.2.4 Fuel Flow

The fuel flows used for calculations were the test cell fuel flows. These account for the extra fuel used at afterburner. In addition, it is our understanding that the gauge on the test cell is calibrated whereas the gauge on the engine is not.

2.3 Other Test Procedures

In addition to the power settings listed in the data identification column, the engine run sheets record other test procedures which, except for shutdown, consist of more than one power setting. These procedures are: transient break-in, transient, ECU (engine control unit), overspeed and shutdown. For the first three procedures, the engine run sheets usually record a start and finish time. The engine run sheets do not give the duration of the procedures for overspeed and shutdown. After consulting operating manuals and talking with test cell operators, we assigned the following power settings and operating times as representative values.

Transient break-in - flight idle, 12 minutes; 14000 rpm, 3 minutes; 15500 rpm, 5 minutes; and IRP, 9.5 minutes; total time 29.5 minutes.

ECU - flight idle and IRP each 3.5 minutes; total time 7 minutes.

Transient - flight idle, 6 minutes; IRP, 1 minute; afterburner, 10 seconds; total time 7.17 minutes.

Overspeed - flight idle, 1 minute; IRP, 1 minute; total time 2 minutes.

Shutdown - flight idle, 5 minutes.

2.4 Emissions of Nitrogen Oxides from Other Test Procedures

The other test procedures contribute to the total amount of nitrogen oxides produces depending upon the time of operation at the various power settings used in the procedure. For each of these procedures, using average fuel flows and thrusts, we combined the fuel used and the nitrogen oxides produced at each of the component power settings. From these values we calculated the fuel use in pounds per hour and an emission index in pounds per 1000 pounds of fuel. Thus, just as individual power settings, each test procedure has a specific rate of fuel consumption and an emission index. For the other test procedures, these fuel uses (pounds per hour) and emission indexes (pounds per 1000 pounds of fuel) are as follows: transient break-in, 4517, 19.04; transient, 2729, 14.08; ECU (engine control unit), 4757, 22.34; overspeed, 4757, 22.34; and shutdown, 996, 3.23.

3. DESCRIPTION OF TABLES

Table 1 summarizes the emissions of nitrogen oxides from the testing of thirteen F404-GE-400 engines. Tables 2 - 14 give more details about the calculations of the individual tests.

In Table 1, column 3 gives the amount of nitrogen oxides formed in a specific engine test, column 4 gives the amount of fuel used in the test and column 5 gives the amount of nitrogen oxides formed for each pound of fuel used. Table 1 gives a mean for the data in column 5. This mean is a correlation coefficient which can be used to estimate the amount of nitrogen oxides coming from an engine test based on the fuel used. Column 6 shows the application of the correlation coefficient. The number in column 3 multiplied by the number in column 5 gives the number in column 6. Finally, column 7 shows the percent difference between the amounts of nitrogen oxides calculated from the emission indexes and the amounts calculated using the correlation coefficient.

Tables 2 - 14 show the development of the values used in Table 1. In Tables 2 - 14, the addition of the amounts in column 7 for all of the rows gives the total amount of nitrogen oxides from the test. This number appears in column 3 of Table 1. Similarily the addition of the entries in column 6 of Tables 2 - 14 (fuel use) gives the numbers recorded in column 4 of Table 1. Finally the division of the amount of nitrogen oxides formed by the fuel used gives the amount of nitrogen oxides per pound of fuel (column 5 of Table 1).

4. CALCULATIONS

The weight in pounds of nitrogen oxides formed during each power setting is determined in the following manner. Using the second entry from Table 2 as an example, first use the thrust of 545 pounds and equation (1) to determine an emission index for the power setting. Thrust values will vary within limits from engine to engine and from test to test. This will change, slightly, the value of the emission index used.

$$y = ae^{bx} \qquad (1)$$

$$y = 2.9747 \times e^{z},$$

where $z = 2.0127 \times 10^{-4} \times 545,$

then $y = 3.32$

Next, for each power setting, multiply the fuel flow by the time at that setting (hours) to obtain the fuel use for the power setting.

955 pounds per hour x 13/60 hours = 206.9 pounds

Finally, divide the fuel used by 1000 (the emission index is for pounds per 1000 pounds of fuel) and multiply by the emission index to obtain the amount of nitrogen oxides produced.

206.9 pounds/1000 x 3.32 = 0.69 pounds

The addition of the amounts of fuel used and nitrogen oxides produced at each power setting, gives the total amounts from the test. Division of the pounds of nitrogen oxides from the test (51.34) by the pounds of fuel used (3858) gives the pounds of nitrogen oxides formed for each pound of fuel used.

$$51.34/3858 = 0.01331$$

In preparing this report, we used an HP-41CV programmable calculator. Appendix B explains how to use this calculator and gives the programs used to make the calculations.

5. CONCLUSIONS

The rate (pounds of nitrogen oxides per pound of fuel) at which the testing of F404-GE-400 engines produces nitrogen oxides can be expressed as an correlation coefficient which then can be used to estimate the amount of nitrogen oxides produced in any test from the amount of fuel used. This coefficient is 0.01556.

Based on the thirteen engine test analyzed, the percentage difference between the amount of nitrogen oxides calculated from the emission indexes and fuel use at the various power settings, and from the total fuel use using the correlation coefficient, varied from -11 to +17. The total amount of nitrogen oxides calculated using this coefficient agreed within 1% of the total amount calculated from the emission indexes.

6. REFERENCES

(1) A. F. Klarman and J. J. Zidzik, "F404-GE-400 Engine Exhaust Emission Test Results, Interim Report," Naval Air Propulsion Center, NAPC-LR-81-10, 30 November 1981

TABLE 1. Summary of nitrogen oxides emissions from the testing of F404-GE-400 engines at NAS Lemoore

Table	Date 1985 (sequence)	NO_x from test, lbs.	Fuel Used in test, lbs.	lbs. NO_x per lb. of fuel used	NO_x, calcd. from mean, lbs.	% difference (a)
2	8 March (578)	51.34	3858	0.01331	60.03	16.93
3	11 March (579)	104.98	7483	0.01403	116.44	10.91
4	22 March (583)	128.92	7399	0.01742	115.13	-10.70
5	26 March (584)	82.65	5907	0.01399	91.91	11.21
6	27 March (585)	50.10	3443	0.01455	53.57	6.93
7	29 March (586)	168.7[illegible]	11493	0.01468	178.83	5.97
8	30 March (587)	131.66	7605	0.01731	118.33	-10.12
9	2 April (588)	101.84	6410	0.01589	99.76	-2.05
10	5 April (589)	140.99	9052	0.01558	140.85	-0.10
11	11 April (590)	152.17	9051	0.01681	140.83	-7.45
12	12 April (591)	141.85	8818	0.01609	137.21	-3.27
13	13 April (592)	140.77	8516	0.01653	132.51	-5.87
14	26 April (595)	119.74	7399	0.01618	115.13	-3.85
	Total	1515.77			1500.53	-1.01
			Mean	0.01556		
			Standard deviation	1.34		

(a) % Diff. = $\frac{\text{pounds of NOx calcd. from mean - pounds of NOx from test}}{\text{pounds of NOx from test}} \times 100$

TABLE 2. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 578, Engine Serial Number 310387, 8 March 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Start/ shutdown	5	-	996	3.23	83.0	0.27
Flight idle	13	545	955	3.32	206.9	0.69
80%	7	2540	2253	4.96	262.9	1.30
89%	3	5945	4850	9.86	242.5	2.39
IRP	7	10190	8514	23.22	993.3	23.06
Afterburner	3(b)	15410	29750	9.22	1487.5	13.71
ECU	4	-	4757	22.34	317.1	7.08
Transient	4	-	2729	14.08	181.9	2.56
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test 3858

Pounds of NO_x per test 51.34

Pounds of NO_x per pound of fuel used in test = 0.01331

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.
(b) Estimated.

TABLE 3. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 579, Engine Serial Number 310254, 11 March 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight Idle	5	360	1050	3.20	87.5	0.28
13000	3	1830	1895	4.30	94.8	0.41
13500	5	2460	2275	4.89	189.6	0.93
14000	4	3550	3000	6.09	200.0	1.22
14500	6	4790	3950	7.82	395.0	3.09
15000	5	6100	4900	10.18	408.3	4.16
15500	6	8205	6700	15.56	670.0	10.43
IRP	2	10075	8400	22.69	280.0	6.35
Trans. brk-in	33	-	4517	19.04	2484.4	47.30
Afterburner	4	15160	30350	9.22	2023.3	18.66
ECU	4	-	4757	22.34	317.1	7.08
Trans.	2	-	2729	14.08	91.0	1.28
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test 7483

Pounds of NO_x per test 104.98

Pounds of NO_x per pound of fuel used in test = 0.01403

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.

TABLE 4. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 583, Engine Serial Number 310097, 22 March 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	3	530	1100	3.31	55.0	0.18
13500	3	2810	2500	5.24	125.0	0.66
15000	3	7000	5552	12.20	277.6	3.39
15500	3	8400	6595	16.18	329.8	5.34
16000	3	10750	8700	25.99	435.0	11.31
IRP	8	10850	8740	26.52	1165.3	30.91
15000	4	6290	4745	10.58	316.3	3.35
Trans. brk-in	32	-	4517	19.04	2409.1	45.87
Afterburner	3(b)	16000	30000 (c)	9.22	1500.0	13.83
ECU	4	-	4757	22.34	317.1	7.08
Transient	5	-	2729	14.08	227.4	3.20
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test	7399	
Pounds of NO_x per test		128.92
Pounds of NO_x per pound fuel used in test = 0.01742		

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.
(b) Estimated.

TABLE 5. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 584, Engine Serial Number 310131, 26 March 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	6	450	1049	3.26	104.9	0.34
80%	6	2600	2323	5.03	232.3	1.17
89%	15	6620	5189	11.30	1297.3	14.66
IRP	1	10560	8592	25.02	143.2	3.58
ECU	19	-	4757	22.34	1506.4	33.65
Afterburner	3(b)	15600	29590	9.22	1479.5	13.64
Shutdown	5	-	996	3.23	83.0	0.27
Transient	18	-	2729	14.08	818.7	11.53
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test	5907	
Pounds of NO_x per test		82.65
Pounds of NO_x per pound of fuel used in test = 0.01399		

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.
(b) Estimated.

TABLE 6. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 585, Engine Serial Number 310079, 27 March 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	8	380	917	3.21	122.3	0.39
Shutdown	1	404	996	3.23	16.6	0.05
89%	5	6190	4957	10.36	413.1	4.28
IRP	6	10620	8699	25.32	869.9	22.03
Afterburner	3(b)	16000	30840	9.22	1542.0	14.22
ECU	5	-	4757	22.34	396.4	8.86
Shutdown	5	-	996	3.23	83.0	0.27
		Pounds of fuel used in test			3443	
		Pounds of NO_x per test				50.10
		Pounds of NO_x per pound fuel used in test = 0.01455				

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.
(b) Estimated.

TABLE 7. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 586, Engine Serial Number 310134, 29 March 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	7	404(b)	993	3.23	115.4	0.37
13500	5	1090	2265	3.77	188.8	0.70
15000	11	3140	5249	5.60	962.3	5.39
16000	4	9621(b)	7985	20.70	532.3	11.02
16250	7	10136(b)	8755	22.97	1021.4	23.46
IRP	2	10472	8755	24.58	291.8	7.17
Trans. brk-in	38	-	4517	19.04	2860.8	54.47
Afterburner	3	-	32950	9.22	1647.5	15.19
ECU	7	-	4757	22.34	555.0	12.40
Transient	5	-	2729	14.08	227.4	3.20
Shutdown	5	-	996	3.23	83.0	0.27
Afterburner	4	-	30870	9.22	2058.0	18.97
Shutdown	5	-	996	3.23	83.0	0.27
Transient	5	-	2729	14.08	227.4	3.20
ECU	5	-	4757	22.34	396.4	8.86
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test	11493	
Pounds of NO_x per test		168.76
Pounds of NO_x per pound fuel used in test = 0.01468		

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel. (b) Estimated.

TABLE 8. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 587, Engine Serial Number 310030, 30 March 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	4	400	980	3.22	65.3	0.21
13500	3	2580	2276	5.00	113.8	0.57
15000	4	6700	5414	11.49	360.9	4.15
15500	3	8150	6410	15.39	320.5	4.93
16000	2	10070	8050	22.66	268.3	6.08
16250	6	10950	8670	27.06	867.0	23.46
IRP	3	10900	8731	26.79	436.6	11.70
150000	1	6040	4666	10.06	77.8	0.78
Trans. brk-in	28	-	4517	19.04	2107.9	40.14
Shutdown	5	-	996	3.23	83.0	0.27
Afterburner	3(b)	16180	31190	9.22	1559.5	14.38
Shutdown	5	-	996	3.23	83.0	0.27
ECU	10	-	4757	22.34	792.8	17.71
Transient	5	-	2729	14.08	227.4	3.20
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test	7605	
Pounds of NO_x per test		131.66
Pounds of NO_x per pound of fuel used in test = 0.01731		

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.
(b) Estimated.

TABLE 9. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 588, Engine Serial Number 310357, 2 April 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	7	409	1099	3.23	128.2	0.41
13500	3	2115	2361	4.56	118.1	0.54
15000	5	6520	5290	11.08	440.8	4.88
15500	8	8095	6565	15.22	875.3	13.32
IRP	3	10000	8133	22.35	406.7	9.09
15000	7	5755	4574	9.49	533.6	5.07
Trans. brk-in	31	-	4517	19.04	2333.8	44.44
Afterburner	1	14950	29528	9.22	492.1	4.54
ECU	6	-	4757	22.34	475.7	10.63
Transient	8	-	2729	14.08	363.9	5.12
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test 6410

Pounds of NO_x per test 101.84

Pounds of NO_x per pound of fuel used in test = 0.01589

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.

TABLE 10. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 589, Engine Serial Number 310320, 5 April 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	5	235	918	3.12	76.5	0.24
13500	3	2110	1925	4.55	96.3	0.44
15000	6	5715	4526	9.42	452.6	4.26
15500	4	7222	5855	12.76	390.3	4.98
16000	6	8735	6993	17.31	699.3	12.11
16250	5	9690	7836	20.99	653.0	13.71
IRP	4	10190	8118	23.22	541.2	12.57
15000	2	5440	4317	8.91	143.9	1.28
Trans. brk-in	26	-	4517	19.04	1957.4	37.27
Afterburner	5	14820	28864	9.22	2405.3	22.18
ECU	13	-	4757	22.34	1030.7	23.03
Transient	8	-	2729	14.08	363.9	5.12
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test 9052

Pounds of NO_x per test 140.99

Pounds of NO_x per pounds of fuel used in test = 0.01558

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.

TABLE 11. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 590, Engine Serial Number 310107, 11 April 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	4	470	1017	3.27	67.8	0.22
13500	5	2815	2457	5.25	204.8	1.07
15000	9	6685	5285	11.45	792.8	9.08
15500	6	8509	6772	16.54	677.2	11.20
16000	7	10560	8667	25.02	1011.2	25.30
IRP	4	10640	8636	25.42	575.7	14.64
15000	3	6250	4754	10.49	237.7	2.49
Trans. brk-in	39	-	4517	19.04	2936.1	55.90
Afterburner	3(b)	148550	30004	9.22	1500.2	13.83
ECU	5(b)	-	4757	22.34	396.4	8.86
Transient	9	-	2729	14.08	409.4	5.76
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test 9051

Pounds of NO_x per test 152.17

Pounds of NO_x per pound of fuel used in test = 0.01681

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.
(b) Estimated.

TABLE 12. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 591, Engine Serial Number 310249, 12 April 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	3	410	875	3.23	43.8	0.14
13500	2	2360	2095	4.79	69.8	0.33
15000	4	5560	4370	9.13	291.3	2.66
15500	5	7475	5725	13.43	477.1	6.41
16000	4	9100	7150	18.64	476.7	8.88
16250	6	10160	7960	23.08	796.0	18.37
IRP	4	10700	8550	25.73	570.0	14.67
15000	7	5250	4000	8.57	466.7	4.00
Trans. brk-in	32	-	4517	19.04	2409.1	45.87
Afterburner	4	15850	30170	9.22	2011.3	18.54
ECU	7	-	4757	22.34	555.0	12.40
Transient	9	-	2729	14.08	409.4	5.76
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test	8818	
Pounds of NO_x per test		141.85
Pounds of NO_x per pound of fuel used in test = 0.01609		

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.

TABLE 13. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 592, Engine Serial Number 310382, 13 April 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	2	335	995	3.18	33.2	0.11
13500	2	2200	2095	4.64	69.8	0.32
15000	3	5725	4700	9.44	235.0	2.22
15500	3	7340	5870	13.07	293.5	3.84
16000	5	9065	7260	18.51	605.0	11.20
16250	3	10080	8100	22.71	405.0	9.20
IRP	7	10340	8310	23.93	969.5	23.20
15000	3	5245	4015	8.57	200.8	1.72
Trans. brk-in	30	-	4517	19.04	2258.5	43.00
Afterburner	4	15160	29350	9.22	1956.7	18.04
ECU	10	-	4757	22.34	792.8	17.71
Transient	10	-	2729	14.08	454.8	6.40
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test 8516

Pounds of NO_x per test 140.77

Pounds of NO_x per pound of fuel used in test = 0.01653

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.

TABLE 14. Emissions of nitrogen oxides from the testing of an F404-GE-400 Engine at NAS Lemoore (Sequence Number 595, Engine Serial Number 310049, 26 April 1985)

Data ident.	Time in mode, min.	Thrust, pounds	Fuel flow, pounds/hr	EI (a)	Fuel use per mode, pounds	Pounds NO_x per mode
Flight idle	3	320	905	3.17	45.3	0.14
13500	2	2440	2180	4.87	72.7	0.35
15000	4	6090	4750	10.16	316.7	3.22
15500	4	7310	5670	12.99	378.0	4.91
16000	3	9175	7280	18.92	364.0	6.89
16250	7	9800	7750	21.46	904.2	19.41
IRP	2	10600	8517	25.22	283.9	7.16
15000	2	5350	4091	8.75	136.4	1.19
Trans. brk-in	26	-	4517	19.04	1957.4	37.27
ECU	10	-	4757	22.34	792.8	17.71
Transient	5	-	2729	14.08	227.4	3.20
Shutdown	5	-	996	3.23	83.0	0.27
Afterburner	3(b)	15800	30250	9.22	1512.5	13.95
Shutdown	5	-	996	3.23	83.0	0.27
Overspeed	2	-	4757	22.34	158.6	3.54
Shutdown	5	-	996	3.23	83.0	0.27

Pounds of fuel used in test 7399

Pounds of NO_x per test 119.74

Pounds of NO_x per pound of fuel used in test = 0.01618

(a) Emission index for nitrogen oxides expressed as pounds of nitrogen dioxide per 1000 pounds of fuel.
(b) Estimated.

Emissions of Nitrogen Oxides from the Testing of F404-GE-400 Engines at Naval Air Station, Lemoore, California

APPENDIX A

Tables IV and V, NAPC-LR-81-10

F404-GE-400 Run Sheets 8 March to 26 April 1985

TABLE IV

F404 EMISSIONS

EMISSION CONCENTRATION (PPM)

Power Condition	CO_2, ppm	CO, ppm	HC, ppm	NO_x, ppm	W_f, lb/hr	FN, lb	EPR	%H	%A
IRP	45790	24.0	<15.0	349.2	8586.9	10548	3.532	13.85	17.59
94%	44230	26.8	<15.0	286.7	8082.6	9957	3.342		
M/C	43040	25.0	<15.0	244.1	7495.1	9201	3.167		
76%	39880	21.7	<15.0	178.9	6541.3	8031	2.902		
63%	36770	21.2	<15.0	131.3	5586.6	6662	2.609		
46%	32090	28.5	<15.0	81.5	4005.2	4883	2.178		
37%	28990	62.3	15.0	56.5	3108.4	3845	1.937		
26%	25380	73.1	18.0	39.7	2422.5	2728	1.710		
20%	22970	139.1	30.0	32.0	1989.2	2069	1.525		
15%	21180	261.9	58.5	25.7	1666.4	1597	1.409		
F/I	15180	1046.7	811.3	-	814.8	234	1.037		
G/I	17210	1352.1	1232.4	6.9	623.9	78	1.016		
MIN	43000	1678.7	354.0	281.4	10250.0	10996	3.513		
MID	75500	1704.4	311.0	296.6	19071.0	14110	3.500		
MAX	106100	1234.3	15.0	299.9	28396.5	15254	3.486		

TABLE V

F404 EMISSIONS

EMISSION WEIGHT RATIOS (G/KG FUEL)

Power Condition	CO_2, g/kg	CO, g/kg	HC, g/kg	NO_x, g/kg	W_f, lb/hr	FN, lb	EPR	%H	%A
IRP	3156	1.05	< 0.31	25.16	8586.9	10548	3.532	13.85	17.59
94%	3156	1.22	< 0.32	21.38	8082.6	9957	3.342		
M/C	3156	1.17	< 0.33	18.71	7495.1	9201	3.167		
76%	3156	1.09	< 0.35	14.80	6541.3	8031	2.902		
63%	3156	1.16	< 0.38	11.78	5586.6	6662	2.609		
46%	3155	1.78	< 0.44	8.37	4005.2	4883	2.178		
37%	3151	4.31	0.48	6.42	3108.4	3845	1.937		
26%	3148	5.77	0.66	5.15	2422.5	2782	1.710		
20%	3136	12.09	1.21	4.56	1989.2	2069	1.525		
15%	3112	24.49	2.54	3.95	1666.4	1597	1.409		
F/I	2815	123.52	44.50	-	814.8	234	1.037		
G/I	2747	137.34	58.18	1.16	623.9	78	1.016		
MIN	2017	74.95	7.35	20.64	10250.0	10996	3.513		
MID	2077	44.21	3.75	12.64	19071.0	14110	3.500		
MAX	3122	23.12	0.13	9.22	28396.5	15254	3.486		

F-404 RUN SHEET

TRT 16 min PAMB 29.25 | OPERATOR AE2 [illegible] | SEQUENCE # 578
INIT 4 min | INSPECTOR AE2 [illegible] | TEST DATE 2-11-92
IDT 4 min | ENGINE S/N 310187 | NOMP ____ PPMFe | ANTI ICE CHECK -4 | TYPE TEST Acc
STARTS 2 | TOTAL SERVICE Full USED 26.7 | RUT N1 141 N2 134

EPR PROGRAM
PAMB x .491 = 14.66
PSL = 14.66 = 2.34 EPR
EPR 2.34
MIN EPR 2.29
MARGIN .05

TMS UNITS
TOTAL CELL WF 29750
ENGINE WF - 2220
CORRECTION - 21630-400
21630 ÷ P3 326 = 6.628
AB UNITS 6.6

ECU CHECKS
PLC FI 36 IRP 99
RGI ____ HPVG's ____
FAN SP. TRX 1 OK 2 OK
N2 LOCKUP OK
FO TEST N1 13293 15 874
FAN OVERSPEED N1 850%

TRANSIENT TEST
FI to IRP 2.5
IRP to AB 1.9
CHOP TO IRP 1.7
FI TO AB 4.1
PLC TEST OK

ROLL-OVER
N2 31
EGP 73
SAP 29
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.3	.4	.3	.4
80%	.3	.4	.2	.5
89%	.5	.7	.4	.7
IRP	.7	.7	.5	.9
AB	.7	.8	.5	1.6

TIME	N1	N2	THRUST	P3	TRT	TSC	N1%	T1C	LPVG	TSHA	EGP	AB	FM	FUEL PSI	OIL TEMP	HPVG	TO	T5 °F	ENG. WF	CELL WF	DATA IDENT
1800	TTL	12.3	TTI	25.9	MAX T5	993	1129	65	EGP	105	WF	709									START
1808	shut down for leak																				
1840	TTL	11.7	TTI	33.2	MAX	T5	991	N2 %		65		EGP	87		WF	695					START 2
1947	[illegible]	[illegible]	545	50	15	329	71	19	-49	329	77	75	32	43	169	29.9	59	638	923	955	FI
2032	9946	13340	2540	117	27	455	80	19	48	489	93	0	56	42	186	15.8	59	924	2222	2253	80%
2107	11594	14765	5905	211	34	542	88	17	19	643	105	15	76	42	218	7.9	58	1198	4638	4850	89%
2110	13115	15930	10190	325	49	801	96	15	0	800	114	16	100	41	243	2.0	58	1473	8705	8514	IRP
2117	13112	15963	15410	326	49	900	95	15	0	800	112	72	123	38	248	1.5	58	1476	8720	29750	AB
2127	[illegible]		ECU	✓																	
1921	End		C.U.	✓	Begin		Trans	✓													
1925	End		Trans	✓																	

REMARKS:

F-404 RUN SHEET

TRT 1hr 43min PAMB 29.84 OPERATOR CPL Cotton SEQUENCE # 579
INPT 15 min. INSPECTOR AO2 Bernard TEST DATE 13 MAR 95
ART 4 min ENGINE S/N 30259 NOAP 1 PPM Fe ANTI ICE CHECK 4 TYPE TEST Break in
STARTS 2 TOTAL SERVICE Full USED ____ RUT N1 183 N2 143

EPR FORMULA
PPMB x .991 = 14.65
PS6 ÷ 14.65 = 3.34 EPR
EPR 3.34
MIN EPR 3.30
MARGIN .04

IID UNITS
TOTAL CELL WF 30350
ENGINE WF - 29945 - 400
CORRECTION - ____
21505 ÷ P3 316 = 68.05
AB UNITS 68.05

ECU CHECKS
PLC FI 34 IRP 98
RGT ____ HPVG's ____
FAN SP. TRX LOK 2 ok
N2 LOCKUP OK
PO TEST N1 13295 15 817
FAN OVERSPEED N1 8325

TRANSIENT TEST
FI & IRP 3.3
IRP & AB 1.1
CHOP TO IRP 1.3
FI TO AB 4.1
PLC TEST OK

ROLL-OVER
N2 3.1
EOP 45
SAF 26
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.2	.2	.3	.1
80%	.5	.3	.4	.2
89%	1.3	.7	.6	.4
IRP	1.6	1.1	.8	.5
AB	1.6	1.9	1.7	1.6

TIME	N1	N2	THRUST	P3	PS6	TSC	N2%	T1C	LPVG	TSHA	EOP	AB	FLM	FUEL PSI	OIL TEMP	HPVG	T0	T5 °F	ENG. WF	CELL WF	DATA IDENT
1949	TTL	10.4	TTI	25.7	MAXTS	983	N2%	64	EOP	107	WF	710									
1954	6100	11782	360	53	13	342	71	17	49	341	82	75	30	43	153	32.7	55	653	906	1050	FI
1959	8323	13070	1830	95	19	446	78	17	48	444	93	0	50	43	176	20.3	54	839	1760	1895	13.000
2002	9260	13527	2460	116	22	491	81	16	48	488	98	0	56	43	188	16.6	54	923	2270	2275	13.500
2007	10132	14018	3550	147	26	544	84	14	42	542	102	2	62	42	198	13.0	54	1009	3017	3000	14.000
2011	11160	14573	4790	183	29	588	87	15	29	596	107	16	71	42	213	10.5	54	1092	4020	3950	14.500
2017	11758	15020	6100	218	34	648	90	15	19	645	109	16	79	42	225	8.5	54	1196	5012	4900	15.000
2022	12497	15580	8205	272	42	724	93	13	9	721	114	16	87	42	238	5.2	54	1330	6770	6700	15.500
2028	13045	16007	10075	322	49	793	95	10	0	790	117	15	101	41	251	2.9	52	1452	8503	8400	IRP
2030	End Steady State			BEGIN TRANSIENT Break-In																	
2103	End TRANSIENT Break-In																				
2107	13570	15942	15160	316	47	793	95	11		791	118	75	129	39	249	0	52	1452	8445	30350	A/B
2111	Begin ECU ✓																				
2115	End ECU ✓ Begin TRANSIENT TEST																				
2117	End TRANSIENT TEST																				
2122	Shut down NL OVERSPEED																				
2223	TTL	616	TTI	18	MAXTS	1002	N2%	65	EOP	88	WF	744									
2223	Shutdown																				

REMARKS:
AB VS PLA = ✓ good
N2% VS EOP = ✓ good
T1 VS T0 = ✓ good
VIBS = Perform VIB SCAN NO VIBS stowed up

F-104 RUN SHEET

TRT 1h2.44min PAMB 29.86 — OPERATOR Mr Rossi — SEQUENCE # 583

IRPT 15 min — INSPECTOR AE2 Bock — TEST DATE 22 march

ABT 13 min ENGINE S/N 310097 — NCNP 0 PPMFe — A.I.I. ICE CHECK 4 — TYPE TEST Break IN

STARTS 2 — TOTAL SERVICE Eu 11 USED 107 — RUT N1 206 N2 156

NASL COI 35

FF FORMULA

PAMB x .491 = 14.66

P56 ÷ 51 = 3.47 EPR

EPR 3.47

MIN EPR 3.35

MARGIN .12

HD UNITS

TOTAL CELL UF 30800

ENGINE UF - 9550

CORRECTION - 21950

21950 ÷ P3329

AB UNITS 66.41 (65.80 check)

ECU CHECKS

PLC FI 95 IRP 28

RGT — HPVG's —

FAN SP. TRX LOK 2 OK

N2 LOCKUP OK

PO TEST N1 13150 15 815

FAN OVERSPEED N1 8400

TRANSIENT TEST

FI to IRP 3.3

IRP to AB 2.0

CHOP TO IRP 1.6

FI to AB 3.9

PLC TEST OK

ROLL-OVER

N2 24

EOP 39

SAF 17

LEAKS 1443

VIB DATA

	#1	#2	#3	#4
FI	.1	.3	.2	.2
80%	.3	.2	.2	.3
89%	.7	.5	.4	.5
IRP	.6	.6	.6	.8
AB	.6	.7	.6	1.0

TIME	N1	N2	THRUST	P3	NOZ	T5C	N2%	T1C	LPVG	T5HA	EOP	AB	F1A	FUEL PSI	OIL TEMP	HPVG	T0	T5 °F	ENG. UF	CELL UF	DATA IDENT
1448	TTL	7.5	TTI	25.6	EOP	103	T5.	999	WF	765	N2%	67									
1452	7060	12115	530	69	15	339	72	22	50	341	93	77	31	59	154	24.7	63	668	1015	1100	FI.
1455	9470	13540	2810	125	23	500	81	22	50	499	95	0	53	59	185	11.8	63	960	2354	2500	13500
1458	12050	15090	7000	237	36	660	90	20	17	660	104	17	68	58	216	3.9	62	1241	5455	5552	15000
1501	12565	15505	8460	275	41	708	93	20	5	710	112	17	72	58	229	.8	62	1320	6500	6595	15500
1504	13195	16060	10750	332	50	803	96	19	0	804	115	13	79	57	240	.0	63	1717	8525	8700	16000
1507	13160	16120	10850	336	51	805	96	17	0	809	115	11	87	57	245	.0	62	1489	8650	8740	IRP
1615	11790	14935	6290	221	34	612	99	20	17	613	104	17	65	58	230	5.0	62	1146	4720	4745	15000
1519		BEGIN	TRANSIENT BREAK IN																		GI
1547		END	TRANSIENT BREAK IN																		
1550	13160	16010	16000	329	49	808	96	18	0	805	115	69	132	45	242	.0	62	1491	8550	30800	A.B.
1600	Begin		ECU	checks																	
1601	END	ECU	Begin	transient		checks															
1604	END	transient	checks																		
1614	NL	OVSPD	shut	DOWN																	
1705	TTL	10 4	TTI	24.3	MAINS	10 4		N0%	65		EOP	71		WF	184						
1715	90%																				
1723	SHUT	DOWN																			

REMARKS:

F-404 RUN SHEET

TRT 1 HR 35 MIN PAMB 29.80 | OPERATOR [redacted] | SEQUENCE # 584
IRPT 15 MIN | INSPECTOR [redacted] | TEST DATE 26 MARCH 85
ADT 6 MIN ENGINE S/N 310131 NOAP 0 PPMFe ANTI ICE CHECK -4 | TYPE TEST PERFORMANCE
STARTS 2 TOTAL SERVICE Full USED 102 RUT N1 206 N2 151

EPP FORMULA
PAMB x .991 = 14.63
PS6 ÷ 14.63 = 3.42 EPR
EPR 3.42
MIN EPR 3.25
MARGIN .17

HD UNITS
TOTAL CELL WF 29590
ENGINE WF - 8580
CORRECTION - 20690
20690 ÷ P3317
AB UNITS 65.2 "65 Book"

CELL CHECKS
PLC FI 85 IRP 29
RUT HPVGS
FAN SP. TRX OKAY OKAY
N2 LOCKUP OKAY
PO TEST N1 15200 T5 815
FAN OVERSPEED N1 7455

TRANSIENT TEST
FI & IRP 5.1
IRP to AB 1.7
CHOP to IRP 3.4
FI to AB 2.2
PLC TEST OKAY

ROLL-OVER
N2 25
EOP 12
SAP 19
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.33	.07	.37	.62
80%	.36	.07	.33	.46
89%	.62	.07	.40	.56
IRP	.74	.07	.53	.79
AB	.83	.07	.63	1.02

TIME	N1	N2	THRUST	T3	T5.6	TSC MAX T5	N2%	T1C	LPVG	TSHA	EOP	AB	P1A	FUEL PSI	OIL TEMP	HPVG	TO	T5 °F	ENG. WF	CELL WF	DATA IDENT
1125		TTC	16.9	TTF	32.6	T5	10	36	EOP	11ϕ		N2%	62		WF		83ϕ				
1141	657ϕ	11900	45ϕ	58	14	332	72	19	5ϕ	33ϕ	8ϕ	76	31	59	168	28.3	56	645	96ϕ	1049	FI
1147	9365	13450	26ϕϕ	117	23	491	81	17	5ϕ	492	97	ϕ2	55	58	186	14.4	57	93ϕ	2280	2323	80%
1153	1172ϕ	15000	662ϕ	222	36	664	9ϕ	17	22	665	113	14	68	57	215	5.9	55	1225	5300	5189	89%
1208	1312ϕ	16ϕ75	1056ϕ	323	5ϕ	800	96	16	0	800	122	17	87	56	239	.9	56	1478	861ϕ	8592	IRP
1209	BEGIN	ECA	CHECKS		END	ECA		CHECKS													
1228	END	ECA	CHECKS																	29590	AB
1233	1311ϕ	16ϕ15	1560ϕ	317	49	798	96	15	0	799	123	72	131	46	225	1.3	57	1476	859ϕ	29590	
	BEGIN		TRANSIENT			CHECKS				1248	5	SHUT		DOWN							
1524	START		TT 4	8.6	TT1	229		Δ12%	65		EOP	70		WF	731		TS	1043			
1532	Resume	TRANSIENT	checks																		
15	END Transient Checks																				
1540	NL OVSPD + SHUT DOWN																				

REMARKS: N2 EOP GOOD
PCA
NEED PAGE 46

F-404 RUN SHEET

TRT 57 min PAMB ____ OPERATOR Nortel SEQUENCE # 585
IRPT 5 min INSPECTOR Collegado TEST DATE 3/27/85
ABT -5 min ENGINE S/N 310079 NOAP 0 PPM Fe ANTI ICE CHECK -5 TYPE TEST ____
STARTS 2 TOTAL SERVICE 14 USED ____ RUT N1 171 N2 161

EPR FORMULA
PAMB x .991: ____
P5 ÷ ____ : ____ EPR
EPR ____
MIN EPR ____
MARGIN ____

AB UNITS
TOTAL CELL WF 16970
ENGINE WF - 8356
CORRECTION - 400
22084 ÷ P3 338 = ____
AB UNITS 65.337 EPR 65.3

ECU CHECKS
PLC FI 28 IRP 85
RGI ____ HPVGs ____
FAN SP. TRX 1 OK 2 OK
N2 LOCK VF OK
PO TEST N1 13224 15 818
FAN OVERSPEED N1 8350

TRANSIENT TEST
FI to IRP ____
IRP to AB ____
CHOP TO IRP ____
FI TO AB ____
PLC TEST OK

ROLL-OVER
N2 29
EOP 42
SAF 19
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.17	0	.19	.27
80%				
89%	.79	____	.38	.01
IRP				
AB	.09	____	.58	1.0

TIME	N1	N2	THRUST	P3	P3 Δ	T5C	N2%	T1C	LPVG	T5HA	EOP	AB	P1A	FUEL PSI	OIL TEMP	HPVG	T0	T5 °F	ENG. WF	CELL WF	DATA IDENT
0929	TTL	7.7	TTI	27.7	MAX T5	968	N29	64	EOP	104	WF	630									
0936	6067	11802	380	64	14	334	71	17	50	340	77	75	31	59.4	167	33.4	54	652	841	917	FI
0°CC	Engine	Shutdown																			
0015	TTL	7.1	TTI	22.7	MAX T5	1035	N28	64	EOP	75	WF	639									
0028	11660	14880	6190	228	34	638	90	15	17	639	110	15	68	58	214	9.8	55	1191	4903	4957	898
0031	13100	16165	10620	341	50	797	97	14	0	798	120	14	87	57	237	3.7	55	1468	8492	8699	IRP
0037	13110	16180	16000	338	50	796	97	13	0	797	119	70	132	46	231	4.0	55	1474	8356	30840	AB
1040	Begin	ECU																			
1045	End	ECU																			
1052	Engine	Shutdown																			

REMARKS:

NAS LEMOORE CQI 181 AIMD

F-404 RUN SHEET

TRT 2hr 51min PAMB 29.82 OPERATOR Cpt Anton SEQUENCE # 586
IRPT ____ INSPECTOR AB3 Collee TEST DATE 4 March 96
ABT ____ ENGINE S/N 310134 NOAP 0 PPMFe ANTI ICE CHECK -4 TYPE TEST Break In
STARTS ____ TOTAL SERVICE FULL USED ____ RDT N1 182 N2 168 .50 .51

EPR FORMULA
PAMB x .491 : 1464
P56 ÷ 51 : 348 EPR
EPR 3.48
MIN EPR 3.34
MARGIN .14

IRD UNITS
TOTAL CELL WF ____
ENGINE WF - ____
CORRECTION - ____
____ ÷ P3 ____
AB UNITS ____

ECU CHECKS
PLC FI 34 IRP 100
REV HPVGS
FAN SP. TRX 1 OK 2 OK
N2 LOCKUP OK
PO TEST N1 13275 15819
FAN OVERSPEED N1 8571

TRANSIENT TEST
FI to IRP 3.2
IRP to AB 1.4
CHOP TO IRP 1.4
FI TO AB 3.8
PLC TEST OK

ROLL-OVER
N2 26
EOP 13
SAP 17.8
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.2	.6	.3	.3
80%	.3	.2	.3	.4
89%	.8	1.7	.4	.7
IRP	.3	.6	.5	.8
AB	.9	.5	.6	1.0

TIME	N1	N2	THRUST	P3	TSC	TSC	N2%	TIC	LPVG	TSHA	EOP	AB	PLA	FUEL PSI	OIL TEMP	HPVG	TO	T5 °F	ENG. WF	CELL WF	DATA IDENT
1257	ST#1	TTL	12	TTI	29.5	N2%	65	WF	674	T5F	1084	EOP	102								
1308	6380	12030		59	15	341	72	21	45	340	78	75	31	59	165	33.9	60	655	895	993	FI
1315	9149	13547	1090	116	23	489	81	21	45	489	91	0	55	59	185	20.2	59	917	2130	2265	13500
1320	11776	15047	3140	222	35	655	90	14	17	655	105	15	78	58	190	11.9	59	1226	5007	5249	15000
1331	12937	15975		310	47	769	95	17	0	770	110	15	90	58	230	5.5	59	1489	7834	7885	16000
1335	13142	16208		334	51	802	97	17	0	805	112	13	100	57	244	4.3	59	1480	8555	8755	16250
1342	13149	16246		334	51	802	98	17	0	802	112	12	100	57	244	4.3	55	1480	8568	8755	IRP
1344	END	STEADY STATE BREAK IN						BEGIN		TRANSIENT			BREAK IN								
1406	END	TRANSIENT BREAK IN																			
1420	13160	16163		327	50	802	96	17	0	802	113	72	130	44	237	4.4	69	1479	8425	32950	AB
1423	BEGIN	ECU ✓																	8400	32400	
1430	END	ECU ✓	BEGIN	TRANS	END		✓												8340	32400	
1435	END	TRANSIENT ✓																			
1449	SHUTDOWN																				
1612	ST#2	TTI	20	TTL	6.8	TS	1178	WP	668	EOP	78	N2	65								
1617																					
1630	≤1	T/O RUN																			
1715	ST#3	TTL	2.0	TTI	22	TS	1218		EOP	72	N2	65	WF	644							

REMARKS: AB

F-404 RUN SHEET

TRT 1hr 95min PAMB 30.01 OPERATOR Norton CAL SEQUENCE # 587
IRPT 15 min INSPECTOR Colles AD3 TEST DATE 30MAR85
ABT 10 min ENGINE S/N 360050 NOAP ____ PPMFe ANTI ICE CHECK -4 TYPE TEST Break in
STARTS 3 TOTAL SERVICE Full USED ____ RUT N1 210 N2 186

EPP FORMULA
PAMB x .491 = 14.73
PS6 ÷ 14.73 = 3.53 EPR
EPR 3.53
MIN EPR 3.20
MARGIN .33

IID UNITS
TOTAL CELL WF 31190
ENGINE WF - 8550
CORRECTION - 400
22240 ÷ P3 335 = ____
AB UNITS 66.39 F7 15 65.6

ECU CHECKS
PLC FI 35 IRP 100
RGI ____ HPVGs ____
FAN SP. TRX 1 OK 2 OK
N2 LOCKUP OK
PO TEST N1 13200 15 823
FAN OVERSPEED N1 8509

TRANSIENT TEST
FI & IRP 3.0
IRP to AB 2.0
CHOP TO IRP 1.8
FI TO AB 3.2
PLC TEST OK

ROLL-OVER
N2 25
EOP 17
SAF 17
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.2	.2	.2	.3
80%	.4	.4	.3	.46
89%	.9	.5	.5	.7
IRP	.56	.97	.6	.85
AB				

TIME	N1	N2	THRUST	P3	MISC	TSC	N2%	TIC	LPVG	TSHA	EOP	AB	FIA	FUEL PSI	OIL TEMP	HPVG	TO	T5 °F	ENG. WF	CELL WF	DATA IDENT
1245	TTL	15	TTI	29	MAX T5	1020	N2	65	EOP	107	WF	690									
1248	6575	11970	3400	60	15	344	69	23	50	345	82	76	31	58	154	30.1	64	666	882	98	FI
1252	9295	13565	2530	120	23	500	78	22	45	500	97	0	57	58	186	15	62	944	2220	2276	13500
1255	11850	15020	6700	230	37	674	89	22	17	673	112	14	81	57	202	6	61	1268	5350	5414	15000
1259	12350	15520	8150	269	42	720	92	21	11	719	116	14	87	56	221	4.3	62	1340	6360	6410	15500
1302	12950	16015	10070	319	48	784	95	20	0	784	120	14	93	56	232	1.5	62	1450	8010	8050	16000
1304	13204	16255	10950	337	51	810	97	19	0	809	122	14	100	56	237	1.1	63	1492	8606	8670	16250
1310	13190	16300	10900	341	52	810	97	19	0	810	122	13	100	56	239	.9	62	1491	8650	8731	IRP
1313	11620	15015	6040	217	34	619	89	21	22	620	108	14	78	57	225	6.6	62	1145	4571	4666	15000
1314	End	Steady state		Break in		Begin		transient		Break in											
1342	End	Transient		Break in																	
1346		shut down																			
1358	ST #2	TTL	4.8	TTI	19	T5	978	WF	650	EOP	75	N2%	67								
1452	13190	16215	16190	335	50	809	97	20	0	808	121	70	130	44	236	1.5	63	1495	8550	31190	A.B.
1417		Shutdown																			
1 APR 85																					
0745	TTL	8.2	TTI	2.5	N2%	65		EOP	111		MAX T5	1195		FF	676						
0750	Begin	Eng	✓																		
0810	Inc	Eng	✓		Start		Trans	✓													
0815	End	Trans	✓																		
0830	Shut	down		NL	over	speed	✓														

REMARKS:

F-404 RUN SHEET

TRT 1HR 50 MIN PAMB 29.84 OPERATOR ADJ ABECCO SEQUENCE # 588
IRPT 16 min 30 sec INSPECTOR ADJ GALLEGOS TEST DATE 3 APRIL 85
ADT 1 HR 10 MIN ENGINE S/N 310357 NCMP ____ FPM Fe ANTI ICE CHECK -4 TYPE TEST BREAK IN
STARTS 01 TOTAL SERVICE FULL USED + 1.0 HRS RUT N1 91.4 N2 15.6"

EPR FORMULA
PPMB X .991 = 14.65
PS6 ÷ 14.65 = 3.20 EPR
EPR 3.20
MIN EPR 3.09
MARGIN .11

HD UNITS
TOTAL CELL HP 29633
ENGINE HP - 8100-900
CORRECTION - 21133
21133 ÷ P3 301 = ____
AB UNITS 66.9

ECU CHECKS
PLA FI 85 IRP 28
RGI ____ HPVGs ____
FAN SP. TRX 1 OKAY 2 OKAY
N2 LOCKUP OKAY
PO TEST N1 13305 15 824
FAN OVERSPEED N1 8630

TRANSIENT TEST
FI to IRP 3.5 SEC
IRP to AB 1.8
CHOP TO IRP 2.7
FI TO AB 3.4
PLA TEST OKAY

ROLL-OVER
N2 24
EGP 22
SAP 17
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.23	.21	.22	.29
80%	.32	.31	.29	.49
89%	.80	.58	.44	.60
IRP	.23	.17	.54	.91
AB	.25	.18	.65	1.07

TIME	N1	N2	THRUST	P3	TIT	T5C	N2%	T1C	LPVG	T5HA	EOP	AB	MA	FUEL PSI	OIL TEMP	HPVG	T0	T5 °F	ENG. WF	CELL WF	DATA IDENT
1100		N2	64	MAX TSC 1043				EOP		88		WF130		TTL P3	8		TTI	36.4			
1110	6933	12038	405	61	15	354	72	31	45	356	75	76	31	56	174	26.3	78	679	995	1099	FI
1118	9531	13596	2615	117	23	524	81	31	45	526	86	0	54	58	200	12.5	78	987	2348	2361	13500
1121	12050	15032	6520	218	36	700	90	29	17	702	99	16	69	56	225	4.9	77	1292	5272	5290	15000
1126	12640	15509	8095	256	41	756	93	29	11	758	103	15	74	56	234	3.0	78	1393	6524	6565	15500
1134	13313	16021	10000	302	46	814	96	29	0	814	105	19	86	56	244	1.5	77	1503	8153	8133	IRP
1137	11764	14913	5755	202	33	646	89	30	22	697	97	15	66	57	232	5.9	77	1194	4675	4574	15000
1144	BEGIN	TRANSIENT		BREAK - IN																	
1215	END	TRANSIENT																			AB
1225	13338	16011	14960	301	46	812	95	30	0	813	107	75	130	45	242	2.4	80	1502	8042	89538	AB
1226	BEGIN	ECA		CHECK																	
1232	END	ECA	CHECK		BEGIN		TRANSIENT			TEST											
1240	END	TRANSIENT		TEST																	
1250	SHUT DOWN		NL	OVER SPEED			9	RAT													

REMARKS: FUEL FILTER PUMP #2
EOP N2
TT GT
PCA

SUGGEST RFI

F-404 RUN SHEET

TRT 2 HOUR 7 MIN PAMB 29.49 OPERATOR AD1 SEQUENCE # 589
IRPT 4 MIN INSPECTOR AD2 GALLEGOS TEST DATE 5 APR 85
ADT 3 MIN ENGINE S/N 310320 NOAP 0 PPMFe ANTI ICE CHECK -4 TYPE TEST BREAK IN
STARTS ONE TOTAL SERVICE FULL USED ____ RUT N1 180 N2 164

EPF FORMULA
PAMB x .991 = 14.48
PS6 ÷ 3.11 = 3.11 EPR
EPR 3.11
MIN EPR 3.03
MARGIN .08

AB UNITS
TOTAL CELL WF 28864
ENGINE WF − 7880
CORRECTION − 20984 − 406
20548 ÷ P3 299 = 68.84
AB UNITS 68.84

ECU CHECKS
PLC FI 33 IRP 100
AGE ____ HPVG's ____
FAN SP. TRX 1 OK 2 OK
N2 LOCKUP OK
PO TEST. N1 13363 T5 821
FAN OVERSPEED N1 8984

TRANSIENT TEST
FI & IRP 1.4
IRP to AB 1.6
CHOP TO IRP 1.5
FI TO AB 4.5
PLC TEST OK

ROLL-OVER
N2 24
ECP 14
SAP 15
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.1	.1	.2	.2
80%	.5	.3	.3	.3
89%	1.0	.9	.4	.5
IRP	1.2	1.2	.5	.7
AB	1.3	.3	.5	.5

TIME	N1	N2	THRUST	P3	T5	T5	N2%	T1C	LPVG	T5HA	EOP	AB	PA	FUEL PSI	OIL TEMP	HPVG	TO	T5 °F	ENG. WF	CELL WF	DATA IDENT
1447		TTL	10 TTI	28	N2	%	65	EOP	77		WF	658		MAX T5			960				
1450	5982	11893	235	46	13	367	72	37	50	367	74	75	32	57	166	336	87	658	835	918	FI
1455	8895	13525	2110	98	19	498	81	35	50	498	86	0	55	57	192	17.5	87	936	1952	1925	13500
1458	11705	15064	5715	195	31	667	90	34	22	663	98	15	79	56	224	8.5	85	1230	4687	4526	1500
1501	12230	15300	7222	234	36	718	93	33	17	719	101	15	87	56	235	5.4	84	1336	5737	5855	15500
1508	12825	15970	8735	269	41	773	95	33	9.1	773	104	15	91	56	242	4.2	85	1498	6836	6993	16000
1514	13129	16231	9690	297	44	810	97	33	5	809	106	14	93	56	248	1.8	86	1995	7796	8836	16250
1519	13372	16342	10150	306	45	813	98	31	0	812	106	-20	100	55	250	1.8	85	1500	8098	8118	IRP
1523	11568	15050	5440	189	29	634	89	34	32	635	96	TS	79	56	224	9.2	87	1190	4378	4317	1500
1529	GI		5 MIN																		
1530		START	TRANSIENT		BREAK		IN														
1601	END TRANSIENT BREAK IN																				AIB
1602	13371	16284	14820	299	43	811	98	32	50	810	107	78	131	45	247	39	86	1502	7880	28864	AIB
1612	START ECU CHECK																				
1925	END ECU CHECKS START TRANSIENT TEST																				
1937	END TRANSIENT TEST																				
1936	SHUT DOWN N1 OVERSPEED																				

REMARKS:
TO VTI GOOD
AQV PLA GOOD
EOP GOOD

F-104 RUN SHEET

TRT 2 HOURS 12 min PAMB 29.87 — OPERATOR ABELLO — SEQUENCE # 590

IRT 15 min 30 sec — INSPECTOR GALLEGOS — TEST DATE APR 11 85

ABT 7 min — ENGINE S/N 310107 — NCAP _____ PPM Fe — ANTI ICE CHECK -4 — TYPE TEST BREAK IN

STARTS ONE — TOTAL SERVICE _____ USED _____ — RUT N1 203 N2 155

TEF FORMULA
PAMB x .491 = 14.68
P5 = 14.68 ÷ 3.33 EPR
EPR 3.33
MIN EPR 3.20
MARGIN .13

IRD UNITS
TOTAL CELL WF 30009
ENGINE WF - 8681 - 400
CORRECTION - 20978
20978 ÷ P3 317 66.17
AB UNITS 66.17 BOIK 66.10

ECU CHECKS
PLC FI 34 IRP 100
RGT _____ HPVG's _____
FAN SP. TRX LOKAY 2 OKAY
N2 LOCKUP OKAY
PO TEST N1 13253 15 815
FAN OVERSPEED N1 8614

TRANSIENT TEST
FI 2 IRP 2.1
IRP to AB 1.4
CHOP TO IRP 1.9
FI TO AB 4.1
PLC TEST OKAY

ROLL-OVER
N2 26
ECP 18
SAP 18
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.17	.12	.25	.33
80%	.32	.29	.34	.48
89%	.60	.41	1.42	.70
IRP	.64	1.0	.5	.7
AB	.66	.71	.65	1.00

TIME	N1	N2	EXHAUST	P3	T5	TSC	N2%	TIC	LPVG	TSHA	EOP	AB	PLA	FUEL PSI	OIL TEMP	HPVG	TO	T5 °F	ENG. WF	CELL WF	DATA IDENT
947		TTL	19.9	TTL	30.5	N2%		65	EOP		92		WF	735	MAX	TS	10	32			START
957	6600	11928	470	58	15	359	72	23	50	361	74	77	31	59	170	29.7	63	696	960	1017	FI
1001	9410	13509	2815	119	23	526	81	23	45	526	89	0	55	58	190	15.7	63	1004	2485	2457	13500
1006	11841	15009	6685	222	36	680	90	21	17	680	101	16	78	58	218	8.3	64	1284	5306	5285	15000
1015	12507	15515	8505	268	42	747	93	22	11	744	104	16	86	57	228	5.8	63	1396	6751	6772	15500
1021	13170	16020	10560	321	49	817	96	21	0	811	107	16	92	57	236	3.2	64	1530	8643	8667	16000
1028	13190	16051	10690	323	49	816	96	20	0	809	107	17	100	57	238	3.3	64	1530	8674	8636	IRP
1032	11727	14968	6250	213	34	659	90	22	22	654	99	15	77	58	228	8.5	65	1202	4934	4754	15000
1035	BEGIN	TRANSIENT			BREAK-IN																
1114	END	TRANSIENT			BREAK-IN																
1121	13216	16029	14685	318	48	820	96	23	0	815	108	67	131	45	233	3.3	67	1532	8626	30004	AB
1141	END	ECA	CHECK		BEGIN			TRANSIENT				TEST									
END	TRANSIENT		TEST		1150																
1259	ENGINE	SHUT	DOWN			OVE	RSPEED		TEST												

REMARKS:
OIL Vs N2% GOOD
PLA VS AB GOOD
VS TIC GOOD

F-404 RUN SHEET

TRT 1hr 45 min PAMB 29.82 — OPERATOR ADL ABello — SEQUENCE # 591-
IRPT 12 min — INSPECTOR AO3 Collec — TEST DATE 12 APR 85
IBT 5 min ENGINE S/N 810249 — NOAP 0 PPMFe — ANTI ICE CHECK -5 — TYPE TEST Block IN
STARTS 1 — TOTAL SERVICE FULL USED 60Z — RUT N1 185 SEC N2 136 SEC

IPP FORMULA
PAMB x .491 = 14.64
P56 ÷ 50 = 3.40 EPR
EPR 3.40
MIN EPR 3.23
MARGIN .17

IBB UNITS
TOTAL CELL WF 30170
ENGINE WF - 8380
CORRECTION = 21790 - 400
21390 ÷ P3 316 67.69
AB UNITS 67.69 (67.00)

ECU CHECKS
PLC FI 29 IRP 85
RUT — HPVG3 —
FAN SP. TRX 1 OK 2 OK
N2 LOCKUP OK
PO TEST N1 13412.5 812 879
FAN OVERSPEED N1 8606

TRANSIENT TEST
FI & IRP 9.7
IRP to AB 11.7
CHOP TO IRP 3.1
FI TO AB 3.5
PLC TEST OK

ROLL-OVER
N2 22
EGP 23
SAF 16
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	.2	.1	.1	.2
80%	.2	.2	.3	.4
89%	.5	.3	.4	.5
IRP	.7	.7	.6	.9
AB	7	7	7	7.0

TIME	N1	N2	THRUST	P3	T5.6	T56	N2%	T1C	LPVG	TSHA	EGP	AB	P1A	FUEL PSI	OIL TEMP	HPVG	TO	T5 °F	ENG. WF	CELL WF	DATA IDENT
	TTL	12.2	TTI	30.2	T5	1099	WF	675	EGP	90	N2%	64								Q	
1302	5728	11720	410	47	15	367	70	31	50	369	76	76	31	55	163	33.0	77	699	812	975	F.I.
1303	9075	13535	2360	105	[illegible]	[illegible]	70	31	50	494	92	0	55	55	190	15.0	77	932	2640	2645	13500
1305	11580	14940	5560	191	31	627	90	28	28	625	103	17	67	54	216	7.0	75	1152	4330	4380	15000
1309	12323	15515	7475	238	38	690	93	29	17	690	105	17	72	54	230	3.0	76	1272	5720	5725	15500
1314	12875	15995	9100	278	44	755	96	27	11	757	108	16	77	54	240	0	76	1343	7190	7156	16000
1319	13074	16250	10160	305	48	795	97	26	5	793	110	12	79	54	245	0	78	1463	7975	7960	16250
1324	13285	16435	10700	322	50	814	99	26	0	815	110	12	87	53	249	0	77	1500	8500	8550	IRP
1328	11490	14990	5250	189	31	575	90	30	28	578	97	16	66	54	237	5.5	76	1086	4000	4000	15000
1331	Decel To G.I.																				
1340	END STEADY STATE Block IN / Begin Transient Block IN																				
1412	END Transient Block IN / Decel To F.I.																				
1415	13310	16385	15850	316	49	811	98	28	0	813	113	71	130	42.042		0	79	1500	8380	30170	AB
1419			Decel To F.I.																		
1425		START EGU CHECK																			
1432		END EGU CHECK / BEGIN TRANSIENT TEST																			
1941		End transient test																			
1446	NL	Overspeed & Engine shutdown																			

REMARKS:

F-404 RUN SHEET

TRT 2 HRS 10 min PAMB 29.86 | OPERATOR ADI ANSELLO | SEQUENCE # 592
IRPT 16 min | INSPECTOR ADI PACIFICO | TEST DATE 13 APR 85
ABT 8 min ENGINE S/N 310382 | NOAP Ø PPM Fe | ANTI ICE CHECK -4 | TYPE TEST BREAK-IN
STARTS 1 | TOTAL SERVICE FULL USED 10 OZ | RUT N1 302.3 N2 146.6

EPF FORMULA
PAMB × .491 = 14.66
PS6 ÷ 14.66 = 3.27 EPR
EPR 3.27
MIN EPR 3.17
MARGIN .08

AB UNITS
TOTAL CELL WF 29350
ENGINE WF - 8175 -900
CORRECTION - 20775
20775 ÷ P3 307 67.67
AB UNITS (67.60)

ECU CHECKS
PLC FI 34 IRP 100
RUT ____ HPVG's ____
FAN SP. TRX OK 2 OK
N2 LOCK UP OK TO
P.O. TEST N1 1342/15 817
FAN OVERSPEED N1 5626

TRANSIENT TEST
FI to IRP 3.7
IRP to AB 1.4
CHOP TO IRP 1.9
FI TO AB 3.3
PLC TEST OK

ROLL OVER
N2 24
ECP 24
SAF 18
LEAKS
0955

VIB DATA

	#1	#2	#3	#4
FI	.2	.2	.2	.2
80%	.3	.2	.3	.3
89%	1.0	.5	.4	.6
IRP	0.9	.7	.6	.8
AB	1.1	.6	.7	1.0

TIME	N1	N2	THRUST	P3	TSFC	TSC	N2%	TIC	LPVG	TSHA	EOP	AB	P1A	FUEL PSI	OIL TEMP	HPVG	TO	T5 °F	ENG. WF	CELL WF	DATA IDENT
1000	SET #1	TTL	10.8	TTI	25		MAX	TIC	1116		EOP	99		NF	695		N2%	64			
1003		START	STEADY	STATE		BREAK-IN															G.I
1005	6162	11907	335	53	14	367	71	31	50	368	83	76	31	56	159	31.7	77	706	871	995	F.I.
1007	8989	13469	2200	105	20	507	81	31	50	508	98	0	56	56	187	17.9	77	955	2015	2095	13500
1009	11710	15025	5725	199	32	653	90	29	22	652	114	16	79	55	212	9.6	77	1225	4685	4700	15000
1012	12362	15545	7340	240	37	712	93	29	17	712	116	16	88	54	228	7.0	76	1323	5875	5870	15500
1015	12880	16028	9065	281	43	768	96	28	5	767	120	16	93	54	237	4.5	76	1420	7295	7260	16000
1020	13197	16299	10080	307	47	813	98	27	5	812	123	12	95	53	241	3.4	76	1499	8102	8100	16250
1023	13299	16508	10340	314	48	813	98	28	0	812	123	14	100	53	245	2.4	76	1500	8313	8310	100
1030	11522	15008	5245	189	30	601	90	30	28	601	107	16	77	55	234	8.5	78	1103	4050	4015	15000
1033		DECEL TO G.I. / END STEADY STATE BREAK-IN																			
1040		BEGIN TRANSIENT BREAK-IN RUN																			
1110		DECEL TO F.I. / END TRANSIENT BREAK-IN RUN																			
1115	13318	16340	15160	307	46	811	98	30	Ø	809	125	71	130	42	240	2.0	79	1499	8175	29350	A/B
1119		DECEL TO F.I.																			
1125		BEGIN ECU CHECKS																			
1135		END ECU CHECK / BEGIN TRANSIENT TEST																			
1145		END TRANSIENT TEST																			
1210		ENG. SHUTDOWN FOR N1 OVERSPEED																			

REMARKS:

F-404 RUN SHEET

TRT 1 hr 44 min PAMB 29.51 OPERATOR Norton, CPL SEQUENCE # 595
IRPT 14 min INSPECTOR Bernard, AD2 TEST DATE 26/19:185
AOT 12 min ENGINE S/N 310049 NOAP ____ PPMFe ANTI ICE CHECK -9 TYPE TEST Breakin
STARTS 3 TOTAL SERVICE FUL USED 602 RUT N1 197 N2 157

PERFORMANCE
PPTR x .991: 14.49
FSE ÷ 14.49 = 3.38 PR
FPR 3.38
MIN EPR 3.18
MARGIN .20

AD UNITS
TOTAL CELL WF 30250
ENGINE WF - 8393
CORRECTION - 400
21457 ÷ P3 312 = 68.77
AB UNITS 68.77 Book 66.2

ECU CHECKS
PLC FI 30 IRP 85
RUT ____ HPVGs ____
FAN SP. TRX LOK 20K
N2 LOCKUP OK
PO TEST N1 13359 15 8516
FAN OVERSPEED N1 8516

TRANSIENT TEST
FI & IRP 4.6
IRP & AB 1.3
CHOP TO IRP 4.1
FI TO AB 4.5
PLC TEST OK

ROLL-OVER
N2 24
EOP 79
SAP 76
LEAKS

VIB DATA

	#1	#2	#3	#4
FI	17		.12	.3
80%	.13		.15	.12
89%	.16		.13	.10
IRP	.9		.17	.85
AB	.1		.17	.1

TIME	N1	N2	THRUST	P3	TSE	T5C	N2%	T1C	LPVG	TSHA	EOP	AB	OIL	FUEL PSI	OIL TEMP	HPVG	TO	T5 °F	ENG. WF	CELL WF	DATA IDENT
1638	N2 8	65	MAXTS	1091	EOP	100	WF	649	TTL	8.9	TTI	32A									
647	5978	11755	320	51	14	355	78	28	49	355	80	77	31	55	168	31.8	71	681	817	905	FI
1650	9245	13570	2490	110	21	492	81	27	48	492	96	5	53	55	189	15.5	71	934	2103	2180	13500
1652	11695	15120	6090	205	33	650	90	25	21	699	111	17	68	55	215	6.1	71	1145	4775	4750	15000
1656	12200	15500	7310	235	37	610	93	25	14	693	112	17	72	54	222	4.2	71	1281	5680	5670	15500
1700	12825	16000	9175	282	44	761	96	24	6	761	116	17	76	54	233	2.3	71	1411	7200	7208	16000
1703	12975	16172	9800	297	46	787	96	23	4	786	116	15	78	53	238	.8	71	1455	7816	7750	16250
1710	13252	16400	10600	319	49	816	98	23	0	815	117	16	87	53	242	.9	70	1502	8511	8517	IRP
1712	11367	14910	5350	188	31	599	90	25	26	600	104	17	65	55	228	7.2	70	1108	4076	4091	15000
1714	End	Steady	State	break-in	+ Begin	transient	Break-in											1<			
1740	End	transient	Break-in	+ Begin	ECU ✓																
1750	End	ECU ✓	Begin	transient																	
1759	Shutdown																				
1848	13235	16276	15800	312	48	811	97	22	0	812	118	75	131	42	233	0	69	1499	8393	30250	AB
1900		shut Down																			
2011	START	IDL	6.9	IDL	20.2	IS	1020	N2	64	EOP	100	WF	675								
2015	shut Down																				

REMARKS:
T1 vs TO good
EOP good
AB vs PLA

BT 118 16250

Emissions of Nitrogen Oxides
from the Testing of F404-GE-400 Engines
at Naval Air Station, Lemoore, California

APPENDIX B

The Use of a Small Programmable Calculator for Estimation of the Amounts of Nitrogen Oxides Produced during the Testing of F404-GE-400 Engines

The Use of a Small Programmable Calculator
for Estimation of the Amounts of Nitrogen Oxides
Produced during the Testing of F404-GE-400 Engines

B1. USE OF THE HP-41C/CV CALCULATOR

A programmable calculator, preferably with a printer, will aid in making estimations of the emissions of nitrogen oxides. The following paragraphs show how to use a Hewlett Packard HP-41C/41CV calculator to make these estimates. The instructions assume that the user knows how to load and run a program. Program NOP requires an HP 82162A Thermal Printer with an HP-IL Module. Program NO does not require a printer. Both programs make the same calculations. The Aircraft Environmental Support Office prefers using program NOP because it provides a permanent record of the data entered and values calculated. Program NO is provided for the convenience of users who do not have a printer. Programs NOP and NO use nine of the keys in the top two rows of the calculator as "local labels" A through J (label G is not used). This means that to use these programs, the calculator must be in "user" mode and must not have user assignments on these keys.

For additional information about these programs or for help in modifying them to meet specific needs, contact:

Aircraft Environmental Support Office, Code 643
Naval Air Rework Facility
Naval Air Station, North Island
San Diego, CA 92135
(Autovon 951 5032, Commercial (619) 437 5032

B2. DESCRIPTION OF PROGRAMS NOP AND NO

The programs make the calculations described in this report. The programs use two storage registers. The functions of the labels are as follows:

Label	Use
I	Initiates the program and sets both registers 00 and 01 to zero. After asking for a sequence number, to identify the test, label I requires the input of data for each power setting used in the test. These data are: time (as minutes), thrust (as pounds), and fuel flow (as pounds per hour). The program first calculates an emission index for nitrogen oxides for the power setting using equation (1). The constants needed for this calculation are in the program. The program next calculates the amount of fuel used for the time at the power setting and adds this amount of fuel to whatever number is in register 00

Label	Use
	(always zero at the start of the data entry). The program next calculates the amount of nitrogen oxides produced by the time of operation at that power setting, using the emission index already calculated, and adds this number to whatever number is in register 01 (again zero at the start of data entry). Thus registers 00 and 01 accumulate the amounts of fuel used and nitrogen oxides produced by the various power settings in the test run. As label I always sets registers 00 and 01 to zero, it must be used only to initiate the determination of fuel and nitrogen oxides from a test.
A to F	Labels A to F are alternate methods for entering data. They are used with test procedures or power settings for which some of the data does not vary. These keys allow faster entry of data.
A	This label calculates fuel use and nitrogen oxides produced for the transient break-in test procedure (see Paragraph 2.3). This test procedure uses an emission index and fuel flow which already has been determined. Thus, the only entry needed is the time of operation for the test procedure.
B and C	These labels make calculations for transient and ECU similar to those made by label A.
D and E	These labels make calculations for overspeed and shutdown similar to those made by label A . In this report, the times at these test procedures usually do not change. Overspeed always is 2 minutes and shutdown usually is 5 minutes. Thus, keys D and E need no data entries.
F	This label is used for afterburner. The emission index for afterburner is not calculated from thrust. Instead a constant value is used. Thus, the only data entries are time and fuel flow.
H	Label H changes a bad entry. It deletes the row of data just entered.
J	Label J determines the total amount of fuel used and nitrogen oxides produced. Label J also calculates the amount of nitrogen oxides produced per pound of fuel used in the test.

B3. INSTRUCTIONS FOR USING PROGRAMS NOP AND NO

The instructions for programs NOP and NO use data from Table 5 of the report. With the calculator at the desired program, start the calculation by the keystroke, I, or by XEQ NOP (or NO).

B3.1 Program NOP

KEYSTROKES	DISPLAY	REMARKS
I	SEQUENCE?	Key in an identifying sequence number. if no number is assigned, a blank space will appear on the printer tape.
584	584	Key in R/S to continue.
R/S	MINUTES?	Key in data from Table 5 starting with the first data row. Key in time.
6	6	Key in R/S to continue.
R/S	THRUST?	Key in thrust.
450	450	Key in R/S to continue.
R/S	FUEL?	Key in fuel.
1049	1049	Key in R/S to continue.
R/S	MINUTES?	The first line of the print-out (6 450 1049) shows the data entered in the order entered. The second line of the print-out (3.26 104.9 0.34) shows the emission index for nitrogen oxides at the power setting used, the pounds of fuel used for the time at that power setting and the amount of nitrogen oxides produced. In a similar manner, key in the next three rows of data.
R/S	MINUTES?	Key in the time at ECU.
19	19	ECU is a special test procedure. It is a combination of more than one power settings. Key in C to continue.
C	MINUTES?	The first line of the print-out identifies the test procedure. The second line of the print-out shows the time and the fuel flow. The third line shows the emission index, the fuel used and the amount of nitrogen oxides produced. Key in R/S to continue.

KEYSTROKES	DISPLAY	REMARKS
R/S	MINUTES?	The next row is afterburner data. It is a special situation in that the emission index used always is 9.22. Key in the time.
3	3	Key in F to continue.
F	A/B FUEL?	Key in the fuel used at afterburner.
29590	29590	Key in R/S to continue.
R/S	MINUTES?	The first line of the print-out identifies the power setting. The second line shows the data entered. The third line shows the emission index, fuel used and nitrogen oxides produced. The next data row is for shutdown. It is a specal situation. Key in E to continue.
E	MINUTES?	This label assigns a time of 5 minutes, an average fuel flow of 996 pounds per hour, and an emission index of 3.23. The first line of the print-out identifies the power sequence. The second line of the print-out shows the time and the fuel flow. The third line shows the emission index, the fuel used and the amount of nitrogen oxides produced. Note that an overspeed operation always is assigned a time of 2 minutes and a shutdown operation usually is assigned a time of 5 minutes. When using a shutdown procedure of other than 5 minutes, enter time, average thrust (404), and fuel flow (996) for flight idle. The next operation is another special situation, transient. Key in time to continue.
19	19	Transient is a special situation It is a combination of more than one power settings. Key in B to continue.
B	MINUTES?	The first line of the print-out identifies the operating sequence. The second line of the print-out shows the time and the fuel flow. The third line shows the emission index, the fuel used and the amount of nitrogen oxides produced. Key in D to enter overspeed data.
D	MINUTES?	The print-out identifies and shows overspeed data. Key in E for shutdown data.
E	MINUTES?	The print-out identifies and shows shutdown data. All data have been entered. Key in J for accumulated data.

KEYSTROKES	DISPLAY	REMARKS
J	SEQUENCE?	The print-out shows the pounds of nitrogen oxides formed during the test, the pounds of fuel used in the test, and the pounds of nitrogen oxides formed for each pound of fuel used. The calculator is ready to repeat the calculations using another test.
H	ENTRY DELETED	Label H removes a bad entry. It must be used immediately after the printing of the second line showing emission index, fuel used and nitrogen oxides produced.
B3.2 Program NO		
I	MINUTES?	Key in the time for the first data row.
6	6	Key in R/S to continue.
R/S	THRUST?	Key in thrust.
450	450	Key in R/S to continue.
R/S	FUEL?	Key in fuel.
1049	1049	Key in R/S to continue.
R/S	EI=	Key in R/S to continue.
R/S	3.26	The display shows the emission index for nitrogen oxides at this power setting. Key in R/S to continue.
R/S	FUEL=	Key in R/S to continue.
R/S	104.9	The display shows the fuel used for the time at this power setting. Key in R/S to continue.
R/S	LBS/MODE=	Key in R/S to continue.
R/S	0.34	The display shows the pounds of nitrogen oxides formed during the operation of the engine at flight idle for 6 minutes. Key in R/S to continue.
R/S	MINUTES?	Enter the other data rows in a similar manner. when using labels A - F to enter data for transient break-in, transient, ECU, overspeed, shutdown and afterburner, the display shows the fuel used and the amount of nitrogen oxides produced by the test procedures. It does not show emission indexes. After entering all data continue with Label J.

J	NOX/TEST=	Key in R/S to continue.
R/S	82.65	The display shows the total amount of nitrogen oxides produced from all of the power settings used in the test. Key in R/S to continue.
R/S	TOTAL FUEL=	Key in R/S to continue.
R/S	5907	The display shows the amount of fuel used in the test. Key in R/S to continue.
R/S	NOX/LB FUEL=	Key in R/S to continue.
R/S	0.01399	The display shows the pounds of nitrogen oxides produced for each pounds of fuel used. The calculation is complete. Key in R/S to restart the program on a new calculation.
R/S	MINUTES?	
H	DELETED	Label H removes a bad entry. It must be used immediately after the numerical display of pounds per mode. Re-enter correct time, thrust and fuel.

B4. LISTING OF PROGRAMS NOP AND NO

B4.1 Program NOP

```
01♦LBL "NOP"
02♦LBL I
03 FIX 0
04 .
05 STO 00
06 STO 01
07 "SEQUENCE?"
08 PROMPT
09 X=0?
10 GTO 00
11 ACX
12♦LBL 00
13 PRBUF
14♦LBL 01
15 "MINUTES?"
16 PROMPT
17 ACX
18 "THRUST ?"
19 PROMPT
20 ACX
21 2.0165
22 1 E-4
23 *
24 *
25 E↑X
26 2.974733
27 *
28 "FUEL?"
29 PROMPT
30 ACX
31 PRBUF
32 X<>Y
33 FIX 2
34 ACX
35♦LBL 03
36 RCL Z
37 60
38 /
39 STO Z
40 RCL T
41 *
42 FIX 1
43 ACX
44 ST+ 00
45 STO Z
46 FIX 2
47 X<>Y
48 FIX 2
49 1 E3
50 /
51 *
52 ACX
53 ADV
54 FIX 1
55 ADV
56 ST+ 01
57 FIX 0
58 GTO 01
59♦LBL J
60♦LBL 02
61 "LBS NOX/TEST ="
62 ACA
63 RCL 01
64 FIX 2
65 ACX
66 ADV
67 ADV
68 "LBS FUEL/TEST ="
69 ACA
70 FIX 0
71 RCL 00
72 ACX
73 ADV
74 ADV
75 "LBS NOX"
76 ACA
77 "/LBS OF FUEL"
78 ACA
79 PRBUF
80 "USED IN TEST ="
81 ACA
82 FIX 5
83 /
84 ACX
85 ADV
86 FIX 1
87 ADV
88 GTO "NOP"
89♦LBL A
90 "TRANS BREAK-IN"
91 4517
92 19.04
93♦LBL 06
94 ACA
95 PRBUF
96 ENTER↑
97 RCL T
98 ACX
99 "  "
100 ACA
101 RCL Z
102 ACX
103 PRBUF
104 RDN
105 X<>Y
106 RCL T
107 X<>Y
108 FIX 2
109 ACX
110 GTO 03
111♦LBL B
112 "TRANSIENT"
113 2729
114 14.08
115 GTO 06
116♦LBL C
117 "ECU"
118 4757
119 22.34
120 GTO 06
121♦LBL D
122 2
123 "OVERSPEED"
124 4757
125 22.34
126 GTO 06
127♦LBL E
128 5
129 "SHUTDOWN"
130 996
131 3.23
132 GTO 06
133♦LBL F
134 "A/B FUEL ?"
135 PROMPT
136 9.22
137 CLA
138 "AFTERBURNER"
139 GTO 06
140♦LBL "CHG"
141♦LBL H
142 FIX 6
143 ST- 01
144 RDN
145 ST- 00
146 94
147 ACCHR
148 " "
149 ACA
150 "ENTRY DELETED"
151 FIX 0
152 ACA
153 ADV
154 ADV
155 GTO 01
156 RTN
157 END
```

B4.2 Program NO

```
01♦LBL "NO"
02♦LBL I
03 .
04 STO 00
05 STO 01
06♦LBL 01
07 "MINUTES?"
08 PROMPT
09 "THRUST ?"
10 PROMPT
11 2.0165
12 1 E-4
13 *
14 *
15 E↑X
16 2.974733
17 *
18 "FUEL?"
19 PROMPT
20 X<>Y
21 FIX 2
22 "EI="
23 PROMPT
24 STOP
25 XEQ 03
26 GTO 01
27♦LBL 03
28 RCL Z
29 60
30 /
31 STO Z
32 RCL T
33 *
34 FIX 1
35 "FUEL="
36 PROMPT
37 STOP
38 ST+ 00
39 STO Z
40 X<>Y
41 1 E3
42 /
43 *
44 FIX 2
45 "LBS/MODE="
46 PROMPT
47 ST+ 01
48 STOP
49 RTN
50♦LBL J
51♦LBL 02
52 "NOX/TEST="
53 PROMPT
54 RCL 01
55 FIX 2
56 STOP
57 "TOTAL FUEL="
58 PROMPT
59 FIX 0
60 RCL 00
61 STOP
62 "NOX/LB FUEL="
63 PROMPT
64 FIX 5
65 /
66 STOP
67 GTO "NO"
68♦LBL A
69 "TRANS BREAK-IN"
70 4517
71 19.04
72♦LBL 06
73 ENTER↑
74 RCL T
75 RCL Z
76 RDN
77 X<>Y'
78 RCL T
79 X<>Y
80 XEQ 03
81 GTO 01
82♦LBL B
83 "TRAN"
84 2729
85 14.08
86 GTO 06
87♦LBL C
88 "ECU"
89 4757
90 22.34
91 GTO 06
92♦LBL D
93 2
94 "OVERSPEED"
95 4757
96 22.34
97 GTO 06
98♦LBL E
99 5
100 "SHUTDOWN"
101 996
102 3.23
103 GTO 06
104♦LBL F
105 "A/B FUEL ?"
106 PROMPT
107 9.22
108 CLA
109 "AFTERBURNER"
110 GTO 06
111♦LBL "CHG"
112♦LBL H
113 ST- 01
114 RDN
115 ST- 00
116 "DELETED"
117 PROMPT
118 GTO 01
119 RTN
120 END
```

B5. EXAMPLE OF PRINT-OUT FROM PROGRAM NOP

```
584
6 450 1049
        3.26 104.9 0.34

6 2600 2323
        5.03 232.3 1.17

15 6620 5189
     11.30 1297.3 14.66

1 10560 8592
       25.02 143.2 3.58

ECU
 19      4757
      22.34 1506.4 33.65

AFTERBURNER
 3      29590
       9.22 1479.5 13.64

SHUTDOWN
 5      996
          3.23 83.0 0.27

TRANSIENT
 18      2729
       14.08 818.7 11.53

OVERSPEED
 2      4757
        22.34 158.6 3.54

SHUTDOWN
 5      996
          3.23 83.0 0.27

    LBS NOX/TEST = 82.65

    LBS FUEL/TEST = 5907

LBS NOX/LBS OF FUEL
  USED IN TEST = 0.01399
```